ABSTRACT

This report explores how climate change will influence air quality in California through changes to meteorology and emissions. The report addresses the challenging nature of the high spatial resolution needed to represent California's air basins and the long analysis periods needed to capture El-Nino Southern Oscillation (ENSO) meteorological cycles. Previous studies have not adequately addressed these issues for California.

Three study methods were employed: (i) model perturbations (O_3 and PM), (ii) statistical downscaling (O_3), and (iii) dynamic downscaling (PM). Model perturbation studies for historical ozone episodes suggest that concentrations increase when maximum daytime temperatures increase, and that the climate change penalty will offset much of the benefit from future emissions control programs. Perturbation studies also suggest that ozone concentrations are relatively insensitive to changes in nighttime temperatures. Nighttime temperatures in California have increased more than daytime temperatures over the past several decades, but the majority of GCMs predict that daytime temperatures will increase in the future in California. For example, daytime temperatures at a height of ~1.5 km (T850) over the San Joaquin Valley (SJV) and South Coast Air Basin (SoCAB) are predicted to increase according simulations performed with the Geophysical Fluid Dynamics Laboratory (GFDL) model developed at Princeton. The statistical relationship between the 1-hr maximum measured ozone concentrations and historical daytime maximum T850 values combined with the GFDL predictions suggest that by the year 2050 California would experience an additional 22-30 days year^{-1} and 6-13 days year^{-1} with ozone concentrations ≥90 ppb under the IPCC A2 and B1 emissions scenarios, assuming criteria pollutant emissions in California remain at 1990-2004 levels.

Climate impacts on ground level airborne particulate matter (PM) concentrations were analyzed by dynamic downscaling of global models. The air quality simulations were carried out with a resolution of 8 km for the entire state of California for the years 2000-06 (present climate) and 2047-53 (future climate). Each period was evaluated using emissions for the year 2000 and for the year 2050. Predictions from over 4000 simulation days suggest that the ENSO signal causes inter-annual variability that is greater than the average shift in PM concentrations between present and future climate conditions. Statistically significant decreases in annual-average $PM_{2.5}$ concentrations (0.5-1.0 $\mu g\ m^{-3}$) over coastal regions of California were predicted due to increased future wind speed during the winter season. Changes to the summer sea breeze system did not have a major impact on coastal PM concentrations. The dynamic downscaling further predicted that extreme 99th percentile PM concentrations will increase (10-20 $\mu g\ m^{-3}$) in the Sacramento Valley (SV) and SJV due to stronger stagnation conditions.

Climate change reduced annual-average population-weighted concentrations of $PM_{0.1}$, $PM_{2.5}$, and PM_{10} in the SoCAB using either year 2000 or year 2050 emissions. Conversely, climate change increased extreme 99th percentile primary $PM_{0.1}$, $PM_{2.5}$, and PM_{10} concentrations in the SV and SJV. Emissions controls such as diesel particle filters or bans on residential wood combustion are effective methods to offset the climate penalty for $PM_{2.5}$ during extreme pollution events.